SAN JACINTO RIVER WASTE PITS TIME CRITICAL REMOVAL ACTION REPORT ON REASSESSMENT OF DESIGN AND CONSTRUCTION

Prepared for

U.S. Environmental Protection Agency, Region 6

On behalf of

McGinnes Industrial Maintenance Corporation

International Paper Company

Prepared by

Anchor QEA, LLC

614 Magnolia Avenue

Ocean Springs, Mississippi 39564

April 2013

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LIST OF ACRONYMS AND ABBREVIATIONS

0.5H:1V	½ horizontal to 1 vertical
10H:1V	10 horizontal to 1 vertical
1H:1V	1 horizontal to 1 vertical
2H:1V	2 horizontal to 1 vertical
ACES	Automated Coastal Engineering System
AOC	Administrative Order on Consent
ASTM	American Society for Testing and Materials
C_c	Coefficient of Curvature
CEM	Coastal Engineering Manual
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
C_u	Coefficient of Uniformity
D_{100}	maximum particle size
D_{50}	median particle size
FOS	factor of safety
GP	poorly graded gravel
GW	well graded gravel
I-10	Interstate I-10
IP	International Paper
MIMC	McGinnes Industrial Maintenance Corporation
mph	miles per hour
NAVD88	North American Vertical Datum of 1988
OMM	Operations, Monitoring, and Maintenance
psf	pounds per square foot
RACR	Removal Action Completion Report
RAWP	Removal Action Work Plan
SJRF	San Jacinto River Fleet
TCRA	Time Critical Removal Action
TxDOT	Texas Department of Transportation
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency

1 BACKGROUND

The San Jacinto River Waste Pits Superfund Site is located on the San Jacinto River, east of Houston in Harris County, Texas. In 2008, the United States Environmental Protection Agency (USEPA) listed the site on the National Priorities List.

McGinnes Industrial Maintenance Corporation (MIMC) and International Paper Company (IP), collectively referred to as the Respondents, entered into an Administrative Order on Consent (AOC) with USEPA in May 2010 (USEPA 2010a) to conduct a Time Critical Removal Action (TCRA). The Action Memorandum for the TCRA (USEPA 2010b, Appendix A) stated that the TCRA was required to stabilize a portion of the site (the TCRA Site) to abate the alleged release of dioxins and furans into the waterway from the impoundments north of Interstate I-10 (I-10), until the site is fully characterized and a remedy is selected (USEPA 2010a). The location of the TCRA Site is depicted on Figure 1.

The design of the TCRA was described in the approved TCRA Removal Action Work Plan (RAWP [Anchor QEA 2010]). The design consists of an armored cap and geotextile and geomembrane liners, placed over the footprint of the impoundments located on the TCRA Site.

TCRA construction started in December 2010 and was completed in July 2011. Following completion of the TCRA, a Removal Action Completion Report (RACR) was prepared and submitted to USEPA[1]. The RACR addressed specific activities required for ongoing operations, monitoring and maintenance of the TCRA. These activities were addressed in the Operations, Monitoring, and Maintenance (OMM) Plan which was submitted to USEPA as an appendix to the RACR and separately approved by USEPA on January 18, 2012. The OMM Plan sets out periodic inspection requirements and describes maintenance procedures for the TCRA cap.

[1] Respondents submitted a Draft RACR to USEPA on September 2, 2011 and subsequently submitted revised versions of the RACR to USEPA in response to USEPA comments, including a Revised Final RACR that was submitted on March 9, 2012 (Anchor QEA 2012). In May 2012, USEPA later elected to make changes to the Revised Final RACR and to issue the RACR, an action as to which Respondents have reserved their rights. The copy of the RACR, as it was issued by USEPA, was received by David Keith, the Respondents' Project Coordinator, via email on August 15, 2012; however, the appendices to the RACR, including the Operations, Monitoring, and Maintenance Plan, were not provided and are assumed to be unchanged from the versions of the appendices submitted to USEPA with the Revised Final RACR on March 9, 2012.

During a regularly scheduled inspection of the TCRA cap on July 20, 2012, visible geotextile was observed in localized small areas of the outer face of the western berm. In accordance with the OMM Plan, USEPA was notified and a maintenance plan was prepared, approved by the USEPA, and implemented by Respondents' contractor. A TCRA Maintenance Completion Report was then prepared and submitted to USEPA on August 27, 2012. On July 31, 2012, USEPA sent a letter to the Respondents requesting that the design and construction of the TCRA be re-assessed in light of the need for maintenance. This report presents the Respondents' reassessment of the TCRA design and construction, and specifically evaluates conditions related to the July 2012 maintenance event to identify the primary cause that triggered the need for maintenance.

Section 2 of this report presents the Respondents' reassessment of the design, including the impact of waves on the armor cap material, and an evaluation of the construction process with respect to the Western Cell and berm area that was the subject of the maintenance conducted following the July 2012 inspection.

Section 3 of this report presents an evaluation of the mechanism that triggered the need for maintenance, as well as other factors that were considered but ruled out as potential causes for the maintenance event.

Subsequent to the July 2012 maintenance event, USEPA prepared a list of technical questions regarding the design and construction of the TCRA and submitted that list to Respondents on October 10, 2012. The Respondents prepared a response to these questions, and presented this response to USEPA during a meeting held on January 16, 2013. Appendix A includes a copy of the materials that were presented to USEPA during the January 16, 2013 meeting.

2 REASSESSMENT OF TCRA DESIGN AND CONSTRUCTION

This section describes the technical reassessment of the design, which specifically addresses, as requested by USEPA, the impact of waves (included in the hydrodynamic reassessment) and the construction process (included in the geotechnical reassessment) with respect to the Western Cell. The original hydrodynamic and geotechnical assessments, which were reviewed by USEPA, are provided in the approved RAWP as technical appendices (Anchor QEA 2010). The following discussion supplements the evaluations described in the approved RACR. Elements specifically re-evaluated under this reassessment include the following:

- Hydrodynamic Reassessment
- Geotechnical Reassessment

2.1 Hydrodynamic Reassessment

The hydrodynamic design for the TCRA cap is presented in the RAWP Appendix I. Since the TCRA was designed, the San Jacinto River Fleet (SJRF) has purchased and begun operations on the property located west and north of the TCRA Site formerly owned by Big Star Barge & Boat Company, Inc. SJRF's operations have resulted in additional tug and barge traffic near the TCRA Site compared to conditions considered in the original design. In addition, a storm event in July 2012 resulted in a set of wave conditions acting on the outside face of the Western Cell berm that caused localized erosion on that berm face. In light of these two events, USEPA has posed questions about the potential for SJRF operations to impact the TCRA, and also requested evaluation of the specific weather conditions surrounding the July 2012 storm and their potential impact on the Western Cell berm. This section provides a reassessment of the TCRA hydrodynamic design with respect to the following:

- Wind/wave evaluation, with a focus on the July 2012 storm event
- Vessel wake evaluation, including typical vessels observed to be transiting the river and the vessel activity associated with SJRF operations
- Evaluation of cap gradation necessary to withstand the resulting wind-generated and vessel-generated waves from the aforementioned reassessment

2.1.1 Wind Wave Evaluation

Winds blowing across the surface of bodies of water transmit energy to the water and waves are formed. The size of these wind-generated waves depends on the wind velocity, the length of time the wind is blowing, and the extent of open water over which it blows (i.e., the "fetch" length; U.S. Army Corps of Engineers [USACE] 1991).

The wind wave evaluation performed as part of the reassessment consisted of the following major components:

1. Obtaining historical wind speeds and directions near the TCRA Site
2. Conducting a statistical evaluation of wind data to estimate the various return interval wind speeds for the largest fetch distances adjacent to the TCRA Site
3. Estimating the corresponding wave height and period from the wind data

2.1.1.1 Wind Data Evaluation

Hourly wind measurements (speeds and direction) from 1973 and updated through July 2012 were obtained from George Bush Intercontinental Airport in Houston, Texas. A wind rose diagram for the data, illustrating how wind speed and direction are typically distributed for the TCRA Site, is shown on Figure 2. The wind data were reported in 2-minute averages every hour. As can be seen in this figure, the prevailing winds in the area are from the south and southeasterly directions, although there can be significant wind events from the north.

The methodology used to estimate winds speeds for wave prediction were consistent with that described in Part II – Chapter 2 of the USACE's *Coastal Engineering Manual* (CEM; USACE 2006). A statistical evaluation was performed on the maximum annual wind speeds to estimate various return interval wind speeds from the north and northwest (the two longest fetch distances that could generate wind-generated waves that could impact the TCRA Site).

Figure 3 shows the fetch distances from the north and northwest used in the calculation.

Five candidate probability distribution functions were fitted to the maximum 2-minute averaged annual wind speeds to develop representative wind speeds with different return periods. The candidate distribution functions evaluated were Fisher-Tippet Type I and Weibull distributions with the exponent k varying from 0.75 to 2.0. The return interval wind speeds used in the design were chosen from the distribution that best fit the data. Figures 4 and 5 show the plots of the computed return interval wind speeds for waves for winds blowing from north and northwest, respectively.

2.1.1.2 Wave Prediction

The USACE Automated Coastal Engineering System (ACES) computer program was used to model wave growth and propagation due to winds (USACE 1992). The ACES program was developed by USACE and is an accepted worldwide reference for modeling water wave mechanics and properties. To compute the wave height for each direction, the wind speed was applied along the fetch distance shown on Figure 3 for each direction. The wave height and period were determined using the ACES Wave Prediction Module. Tables 2-1 and 2-2 summarize the results for winds from the north and northwest, respectively.

Table 2-1
Computed Significant Wave Heights and Periods for Winds Blowing from the North
(0.8-mile fetch length)

	2-year	5-year	10-year	25-year	50-year	100-year
Wind Speed (miles per hour)	26.9	33.0	37.0	42.1	45.9	49.7
Significant Wave Height (feet)	0.71	0.88	0.99	1.13	1.24	1.34
Wave Period (seconds)	1.49	1.60	1.67	1.75	1.80	1.85

Table 2-2
Computed Significant Wave Heights and Periods for Winds Blowing from the Northwest
(1.4-mile fetch length)

	2-year	5-year	10-year	25-year	50-year	100-year
Wind Speed (miles per hour)	29.2	34.3	37.7	41.9	45.1	48.2
Significant Wave Height (feet)	0.99	1.17	1.28	1.42	1.53	1.63
Wave Period (seconds)	1.80	1.91	1.97	2.05	2.10	2.15

Note: In the ACES Wave Prediction Module, the 2-minute averaged wind speeds input to ACES were converted to 15-minute averaged wind speeds in the wave generation model as the wave generation process tends to respond to 15-minute interval wind speeds because shorter duration gusts are generally not sufficient for significant wave generation.

Because the estimated 100-year wind speed from the north (49.7 miles per hour [mph]) was below the maximum wind speed measured (53.0 mph), a calculation of the wave height and period was performed using the maximum measured wind speed. The computed significant wave height and period for a wind speed of 53.0 mph from the north was 1.43 feet and 1.90 seconds, respectively.

Based on this evaluation, wind-generated significant wave heights could range from 0.71 to 1.63 feet.

2.1.2 Vessel Wake Evaluation

Waves can also be generated by a boat moving through the water. These vessel-generated waves are often referred to as wakes. An evaluation was performed to estimate the potential vessel-generated wake heights associated with the tugboats that may operate in the river near the TCRA Site, and in particular in the vicinity of the SJRF barge fleeting operations that were established near the TCRA Site, subsequent to the original TCRA design. With respect to the July 2012 maintenance event, consideration of vessel-generated wake impacts is conservative because there is limited potential for such waves to impact the area of the cap where the July 2012 maintenance event occurred. In this area of the TCRA Site, the limited water depth prohibits large vessels from operating close to the cap.

Based on information provided by local vessel operators, the vertical clearances of bridges limit river operations to smaller tugboats north of I-10 and the tugboats that operate in this area typically move at speeds between 2 and 4 knots (2.3 to 4.6 mph), which minimizes vessel wakes ("no wake") but allows for steerage and control. Local vessel operators also state that the largest tugboats that operate north of I-10 adjacent to the TCRA Site are typically 400 to 800 horsepower class craft. These tugboats operate in the main channel of the San Jacinto River. Based on bathymetric surveys conducted in the vicinity of the TCRA Site, there is a 26-foot-deep channel located 250 feet east of the TCRA Site, in a 20-foot-deep channel located 950 feet northeast of the TCRA Site, and in a 16-foot-deep channel located 1,350 feet north of the TCRA Site.

Based on a review of the river bathymetry and the location of the SJRF fleeting area, tugboats operating to support the SJRF barge fleeting activities operate in 12 to 16 feet of water approximately 430 feet or more, north and northwest of the TCRA Site (Figure 6). In a report entitled "Final Sampling and Analysis Plan for Pre-Construction Baseline Site Assessment, San Jacinto River Fleet Property, Harris County, Texas," (Tolunay-Wong, 2012), SJRF has proposed to install a line of pylons approximately 430 feet from the TCRA Site, physically separating SJRF operations from the TCRA Site.[2] Figure 6 provides a depiction of the limits of the SJRF operations, assuming installation of the pylons.

The TCRA Site is also marked with floating buoys located around the perimeter of the eastern cell. These buoys provide for an additional visible warning to vessel operators to minimize the potential for inadvertent vessel operations in close proximity to the cap.

The Sorensen-Weggel method (Sorensen and Weggel 1984; Weggel and Sorensen 1986) was used to estimate potential vessel wakes for tugboats. The Sorensen-Weggel method is an empirical model (developed from available laboratory and field data on vessel-generated waves) used to predict maximum wave height as a function of vessel speed, vessel geometry, water depth, and distance from the sailing line. This model is applicable to various vessel types (ranging from tugboats to large tankers), vessel speeds, and water depths. The method calculates the wave height generated at the bow of a vessel as a function of the vessel speed, distance from the sailing line, water depth, vessel displacement volume, and vessel hull geometry (i.e., vessel length and draft).

For the vessel wake calculation, a tugboat with a length of 75 feet and a displacement of 7,800 cubic feet was used. This vessel size is typical of tugboats that can physically fit beneath the relatively low I-10 bridge, and was selected for the design evaluation based on conversations with local marine contractors who operate tugboats in the San Jacinto River upstream of I-10. The vessels were conservatively assumed to operate 250 to 1,000 feet from the TCRA Site. Water depths used in the calculation ranged from 12 feet to 26 feet. As described above, the vessels operate at speeds from 2 to 4 knots (essentially a “no wake zone” speed). A vessel wake calculation was performed for vessels travelling at the high end of the expected speed, 4 knots. An additional scenario was considered for vessels travelling at 8 knots, this higher speed representing a conservative case that is expected to overestimate potential wake impacts.

Table 2-3 presents a summary of the results of the vessel-generated wave evaluation.

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[2] Nothing contained in this Report is intended to acknowledge that Respondents concur in the appropriateness or sufficiency of the proposed line of pylons by SJRF as a measure to address impacts from SJRF’s operations.

Table 2-3
Vessel-generated Wave Heights

Vessel Class	Water Depth (feet)	Vessel Speed (knots)	Distance from Sailing Line (feet)	Wave Height (feet)
Tugboat operating in the river channel	16	4	250	0.0
			1000	0.0
		8	250	1.0
			1000	0.6
	26	4	250	0.0
			1000	0.0
		8	250	1.1
			1000	0.7
Tugboat operating at the SJRF barge fleeting area	12	4	430	0.0
		8		0.8
	16	4	430	0.0
		8		0.8

The results indicate that vessels wakes at the TCRA Site would be less than 1.2 feet.

In summary, wind-generated waves are estimated to be less than 1.7 feet, and vessel generated wakes are expected to be less than 1.2 feet at the TCRA Site, which is less than the 2-foot wave height considered in the RAWP for the TCRA design.

2.1.3 Evaluation of Armor Layer Material

Due to the amount of turbulence generated by breaking waves in the surf zone, the armor layer was modeled in the TCRA design as a rubble mound berm; that is, a sloped berm (or revetment) consisting of rock. Armor stone for sloped berms was sized using guidance from USACE (USACE 2006) as part of the original TCRA design. The USACE guidance was used because the methodology to evaluate armor stone sizes for sediment caps presented in USEPA's design guidance (Maynord 1998) does not consider the effects of waves breaking on a cap, as would be the case for the sloped berms at the TCRA Site. The same methods were used in performing the reassessment of the design described in this report. The surf zone is defined as the region extending from the location where the waves begin to break to the limit of wave run-up on the shoreline slope. Within the surf zone, wave-breaking is the dominant hydrodynamic process (USACE 2006).

The ACES Rubble Mound Revetment Design Module was used to compute the necessary armor stone gradation and thickness in the surf zone. The ACES methodology is based on van der Meer's (1988) paper titled *Deterministic and Probabilistic Design of Breakwater Armor Layers*. The ACES assumes that the waves would propagate and break on the slope of the armor layer. The structure was assumed to be permeable, thereby minimizing wave reflection. Stable particle sizes (i.e., armor sizes) were evaluated using the model for slopes ranging from 10 Horizontal to 1 Vertical (10H:1V; the flatter areas being covered at the TCRA Site) to 2 Horizontal to 1 Vertical (2H:1V) (the steepest design slopes along some of the existing berm faces).

Revetments used for coastal protection projects are often designed allowing for some movement of the armor layer, which could necessitate maintenance over time. The revetment design methodology allows consideration of variable amounts of displacement (movement) of the armor layer. The amount of displacement considered can be categorized as follows:

- No Displacement: no armor stone displacement due to wave energy
- Minor Displacement: minimal movement (less than 5 percent) of armor stones displaced due to wave energy and potentially redistributed within or in the near vicinity of the armor layer
- Intermediate Displacement: displacement ranges from moderate to severe; armor stones are displaced

The TCRA armor was designed for very little movement (Anchor QEA 2010) also referred to as the "Minor Displacement" scenario in the rubble mound design guidance. The Minor Displacement scenario is the same as that applied at other Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) cap sites (e.g., Onondaga Lake Superfund Site in Syracuse, New York; Lower Fox River Superfund Site in Green Bay, Wisconsin), to ensure protectiveness.

The No Displacement and Minor Displacement scenarios were re-evaluated for slopes ranging from 10H:1V to as steep as 2H:1V using a wave height of 1.63 feet and wave period of 2.15 seconds, the maximum wave height and wave period shown in Tables 2-1 and 2-2. Recycled concrete (the armor material used in cap type B/C) and natural stone (the armor material used in cap types C and D) were separately considered due to the varying unit weight for each of these aggregates.

Tables 2-4 and 2-5 present the computed median and maximum particle sizes and acceptable ranges of layer thickness for the specific materials, based on the ACES calculation.

Tables 2-4 and 2-5 show aggregates (either recycled or natural rock) with a maximum particle size (D_{100}) less than 12 inches and a median particle size (D_{50}) less than 7 inches, and a thickness range of 8 to 13 inches, will protect against waves in the surf zone at the TCRA Site, but over time may require some isolated maintenance such as placing additional materials in pockets of erosion.

Table 2-4
Median (D_{50}) and Maximum (D_{100}) Particle Size and Thickness - Significant Wave Height of 1.63 feet and Period of 2.15 Seconds - Natural Stone Materials

Particle Size/Thickness (inches)	Natural Stone[1]			
	10H:1V		2H:1V	
	No Displacement	Minor Displacement [2,3]	No Displacement	Minor Displacement [2,3]
D_{50} (median particle size)	7.4	2.4	9.6	5.3
D_{100} (maximum particle size)	11.8	3.7	15.4	8.3
Range of Thickness of Armor Layer[4]	12 to 15	4 to 5	15 to 19	8 to 11

Notes:
1. Assumes a unit weight of 165 pounds per cubic foot.
2. Computed using No Displacement and Minor Displacement scenarios. Minor displacement refers to minimal movement of the armor stones under extreme wave action. Repairs associated with such events (if any) would be handled as part of a maintenance program.
3. Minor Displacement was the design scenario for the TCRA cap armor.
4. Thickness ranges based on guidance from Maynord (1998) and USACE (1995).

Table 2-5
Median (D_{50}) and Maximum (D_{100}) Particle Size and Thickness -
Significant Wave Height of 1.63 feet and Period of 2.15 Seconds -
Recycled Concrete Materials

Particle Size/Thickness (inches)	Recycled Concrete[1]			
	10H:1V		2H:1V	
	No Displacement	Minor Displacement[2,3]	No Displacement	Minor Displacement[2,3]
D_{50} (median particle size)	9.2	2.9	12.0	6.5
D_{100} (maximum particle size)	14.6	4.7	19.1	10.3
Range of Thickness of Armor Layer[4]	15 to 19	5 to 6	19 to 24	11 to 13

Notes:
1. Assumes a unit weight of 145 pounds per cubic foot.
2. Computed using No Displacement and Minor Displacement scenarios. Minor displacement refers to minimal movement of armor stones under extreme wave action. Repairs associated with such events (if any) would be handled as part of a maintenance program.
3. Minor Displacement was the design scenario for the TCRA cap armor.
4. Thickness ranges based on guidance from Maynord (1998) and USACE (1995).

The results of the hydrodynamic reassessment indicate that wind-generated waves and vessel wakes are expected to be less than 2 feet at the TCRA Site. Recycled concrete aggregate placed in flatter areas of the TCRA Site (with a slope of 10H:1V or flatter) with a D_{100} of 5 inches, a D_{50} of 3 inches and a thickness range of 4 to 6 inches will protect against wave attack. This result is consistent with the specifications used in the TCRA for Armor Cap A, as presented in the RAWP and summarized in Table 2-6.

Both natural stone aggregates and recycled concrete aggregates on slopes 2H:1V or flatter with a D_{100} less than 12 inches and a D_{50} less than 7 inches, and a thickness range of 8 to 13 inches will protect against wave attack on slopes with minor displacement. This result is consistent with the specifications used in the TCRA design for Armor Caps B/C, C, and D, as presented in the RAWP and summarized in Table 2-6.

Table 2-6
TCRA Design Cover Material Gradation and Thickness Requirements[1]

Material Designation	Material Type	D_{50} (inches)	Minimum Cover Thickness (inches)
Cap A	Recycled concrete	3	12
Cap B/C	Recycled concrete	6	12
Cap C	Natural stone	6	12
Cap D	Natural stone	8	18
Cap D(24)	Natural stone	8	24

1. Requirements the same as presented in the RAWP and as constructed, based on gradation testing of construction materials.

2.2 Geotechnical Reassessment

This section describes re-evaluation of the following specific geotechnical engineering issues:

- Gradation of the armor rock
- Stability evaluation of the western berm

2.2.1 Gradation of the Armor Rock

During USEPA's review of the July 2012 TCRA maintenance event, questions were raised about the Coefficient of Uniformity (C_u) and Coefficient of Curvature (C_c) of the armor rock gradations placed at the TCRA Site. The C_u and C_c are calculated values comparing the relative percentage of certain size materials in the mixture, and are used to assess whether the material is classified as well graded gravel (GW) or poorly graded gravel (GP) in accordance with the American Society for Testing and Materials (ASTM) standard D 2487.

C_u is defined as follows:

$$C_u = \frac{D_{60}}{D_{10}}$$

where:

D_{60} is the diameter of materials at 60 percent passing

D_{10} is the diameter of materials at 10 percent passing

C_c is defined as follows:

$$C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

where:
D_{60} and D_{10} are defined as above
D_{30} is the diameter of materials at 30 percent passing

For gravel size materials to be classified as well-graded (GW, per the Unified Soil Classification System [USCS], ASTM D 2487), the following criteria should be met:

$$C_u > 4 \quad and \quad 1 \leq C_c \leq 3$$

Table 2-7 summarizes the results of the gradation evaluation for the various armor rock materials used in the TCRA, based on the sieve analyses of the material, submitted by the TCRA contractor prior to construction and provided in the RACR.

Table 2-7
Summary of Armor Rock Gradation Evaluation

Armor Rock Class	C_u	C_c	USCS Classification[1]
A	60	1.7	GW
B/C	> 200	> 100	GP[2]
C	1.5	1	GP
D	1.4	1	GP

Notes:
1. ASTM D 2487
2. C_u and C_c calculations based on a limited number of sieves in the gradation report

By USCS classification, the larger-sized cap materials (armor rock class B/C, C, and D) classify as GP. Such classification is consistent with typically recommended gradations in standard specifications for riprap materials. For example, the Texas Department of Transportation (TxDOT) recommended gradation for Riprap (TxDOT Item 432) classifies as GP when the C_u and C_c are computed in accordance with the USCS. Thus, the armor rock as designed is considered to have an appropriate gradation to function as cap armor for the TCRA. Further, the Respondents' TCRA contractor demonstrated that the armor rock gradation as procured was in conformance with the design in their pre-construction gradation submittals. Copies of these submittals are included in Appendix L of the RACR. A tabular summary of TCRA construction submittals and dates transmitted to USEPA is provided in Appendix B.

2.2.2 Western Berm Stability Evaluation

During a regularly scheduled TCRA cap inspection in July 2012, geotextile was found to be visible in isolated small areas on the outside face of the western berm. Detailed mapping of these areas (Figure 7) showed that the visible geotextile was correlated with areas of the western berm face wherein the subgrade appeared to be steeper than the design 2H:1V. These areas were limited to short vertical heights (generally within 1 to 2 vertical feet). The overall slope of the western berm face, as measured from the toe of the berm to the crest of the berm was 2H:1V or flatter.

Based on these July 2012 inspection observations, USEPA initiated a review of the TCRA design and construction. As part of USEPA's review of the TCRA design, questions were posed regarding the potential effect of construction equipment operations on the stability of the western berm during cap construction. This section presents the results of slope stability evaluations for the western berm during TCRA construction and for the long-term condition, specifically addressing localized areas of the western berm that may have been steeper than the design slope of 2H:1V.

The stability of the berm slope was modeled for the two scenarios (during construction and long-term) using limit-equilibrium methods coded in the SLIDE 6.0 software package by Rocscience Corporation. Limit-equilibrium methods are commonly performed as the geotechnical engineering standard of practice for assessment of slope stability. As a conservative evaluation of stability, the maximum western berm height, coupled with an over-steepened western berm core assumed to be ½ horizontal to 1 vertical (0.5H:1V), was considered in the evaluation.

Results of the stability evaluations were compared to relevant design criteria where applicable. Published design criteria (i.e. target factors of safety [FOS]) are not available for the temporary, "during construction" condition where loads are transitory. However, for FOS greater than 1.0, a slope is considered to be stable with respect to sliding (USACE 2003). Thus, for the "during construction" evaluation, a FOS greater than 1.0 was considered appropriate.

USACE (USACE 2003) does provide guidance for target long-term FOS for slope stability evaluation. The criteria published by USACE were developed for the evaluation and design of dams, where the potential consequences of failure are significant. Thus, it is considered conservative to use such criteria for evaluation of the western berm. For the long-term evaluation, the target FOS recommended by USACE is 1.5.

During construction, excavators operated on wooden crane mats in the Western Cell. Based on information from the TCRA contractor USA Environment, and as observed during on-site Construction Quality Assurance performed by Anchor QEA, the wooden mats were 8 feet wide by 16 feet long, and the equipment operated on a minimum of three mats at any time to distribute the equipment surcharge. For the "during construction" scenario, the following modeling assumptions were used:

- Berm height = 4 feet
- Soft clay berm core
- Slope angle of berm core = 0.5H:1V (over-steepened)
- Geotextile and geomembrane placed over the soft clay berm core on the berm face
- Geotextile to soil contact on the river side of the western berm
- Armor rock placed over the geotextile
- Armor rock thickness = 1 foot
- Armor rock outer slope angle = 2H:1V
- Construction surcharge from CAT 324 DL long-reach excavator
    - Operating Weight = 61,600 pounds
    - Distributed Surcharge Load = 160 pounds per square foot (psf)

Table 2-8 summarizes the soil and material models used in the limit-equilibrium evaluation. In this evaluation, the FOS was computed using Spencer's method, which satisfies both force and moment equilibrium for each slip surface evaluated. Geotextile interface model parameters were developed based on published literature values (Layfield 2013). Soil model parameters are consistent with those used in the geotechnical evaluation provided in the RAWP, which also describes how those parameters were developed. Undrained soil parameters were used to model the clay berm core for the "during construction" evaluation.

This assumes that the excess pore pressures are not allowed to dissipate during the temporary, transitory construction loading because of the fine-grained nature of these soils. For the long-term evaluation, drained (i.e., effective stress) soil parameters were used to model the fine-grained soils, in accordance with USACE guidance (USACE 2003).

Table 2-8
Summary of Limit Equilibrium Materials Properties

Material	Saturated Unit Weight (pcf)	Soil Model	Model Inputs	
			Friction Angle (degrees)	Cohesion (psf)
Soft Silt and Clay During Construction (Short-term)	107	Vertical Stress Ratio	0	$0.44 * \sigma_v' \geq 40$
Soft Silt and Clay Long-term	107	Mohr Coulomb	15	100
Armor Cap Material B/C	125	Mohr Coulomb	38	0
Geotextile[1]	N/A	Mohr Coulomb	20	0

Notes:

1. Geotextile model is based on interface friction between the textile and the soil.
2. N/A = not applicable.
3. σ_v' = in situ vertical effective stress.

Based on the results of the stability analyses, the western berm would have had a FOS greater than 1.0 during construction, which is an indication that construction activity would not have caused instability. The static long-term FOS is greater than 1.5 based on the stability model for the long-term condition, which meets the target criteria published by the USACE (2003). Results of the stability evaluation are presented in Table 2-9.

Table 2-9
Results of Limit Equilibrium Evaluation

Conditions	During Construction (Short-term)	Post Construction (Long-term)
Slip surface shape	Non-circular	Non-circular
Factor of Safety	1.14	1.6
FOS target per USACE EM 1110-2-1902	N/A[1]	1.5

Notes:

1. There is no published FOS guidance for the transitory loading conditions during construction. For the short-term "during construction" evaluation, a target FOS of 1.0 or greater was selected. A FOS greater than 1.0 indicates that the slope will be stable with respect to sliding (USACE 2003).

2.3 Summary Conclusions of Reassessment

Based on the evaluations described in this section, this section summarizes the conclusions of the TCRA reassessment.

2.3.1 Hydrodynamic Conclusions

The results of the hydrodynamic reassessment indicate that wind-generated waves and vessel wakes are projected to be less than 2 feet at the TCRA Site. This is consistent with the original design as documented in the RAWP.

The recommended aggregate size was reassessed based on armor design factors of safety and design procedures recommended by the USACE, which have been used at other CERCLA cleanup sites, and takes into consideration protectiveness, implementability, and long-term maintenance costs.

Recycled concrete aggregate placed in flatter areas of the TCRA Site with a D_{100} of 5 inches, a D_{50} of 3 inches and a thickness range of 4 to 6 inches will protect against wave attack. This result is consistent with the specifications used in the TCRA for Armor Cap A and with the cap as constructed. Both natural stone aggregates and recycled concrete aggregates with a D_{100} less than 12 inches, a D_{50} less than 7 inches and a thickness range of 8 to 13 inches will protect against waves on slopes of 2H:1V or flatter with an appropriate factor of safety and protectiveness. This result is consistent with the specifications used in the TCRA design for Armor Caps B/C, C, and D and with the cap as constructed.

Table 2-6 summarizes the TCRA aggregate size and cap thickness specifications. All armor rock and recycled concrete materials were placed to a thickness equal to or greater than the thickness requirements summarized in Table 2-6 during the TCRA construction.

Based on the hydrodynamic evaluation, the sizes of the armor rock and recycled concrete materials selected during the TCRA design are appropriately protective during the range of wind, wave and wake actions modeled. Modification of the cap armor gradation or thickness is not necessary to ensure the continued protectiveness of the armor cap.

2.3.2 Geotechnical Conclusions

The gradation of the armor cap is a USCS classification of GP, which is the same as the classification of standard specification riprap materials from TxDOT and other agencies.

Based on the geotechnical berm stability re-evaluation, during construction, the FOS for equipment operating on mats near the berm was higher than 1.1, which is an indication that equipment operations would not have caused slope failures on the berm. In the long-term case, the FOS of the berm is greater than recommended by USACE guidance indicating that the armor rock overlay provides overall berm stability.

3 EVALUATION OF JULY 2012 EVENT

Following the July 2012 storm and associated maintenance event, USEPA requested an assessment of the factors that triggered the need for maintenance. This section describes the variety of causes considered, and the conclusions drawn after considering these potential causes.

3.1 Summary of All Factors Considered

Table 3-1 summarizes the factors that were considered as potential causes for the maintenance need. The assessment of these causes is presented in the subsequent sections of this report. Potential causes were categorized as follows, based on the results of our evaluation:

- Primary Cause
- Contributory Cause
- Other Potential Causes

Table 3-1
Summary of All Causes Considered

Potential Cause	Reason Considered
Cap subgrade slopes	Cap subgrade slopes steeper than the 2H:1V design could present a "preferential" pathway for armor rock sliding on the subgrade
Soft berm foundation soils	Soft foundation soil conditions could potentially lead to deep-seated (global stability) failure of the berm
Armor cap gradation	Cap armor gradation smaller than specified could be subject to movement under wave attack
Excessive construction loads	Excessive surcharge loading on the top of the berm during construction could cause a bearing capacity failure in the berm, or result in localized "bulging" or displacement of the berm
Elevated river currents	River currents exceeding the design assumptions could potentially move the armor rock
Wind-generated waves	Wind-generated waves exceeding the design assumptions could potentially move the armor rock
Vessel wakes	Vessel wakes exceeding the design assumptions could potentially move the armor rock
Anthropogenic damage	Human activities on the cap itself (digging, boat anchoring) could result in armor rock being moved
Impact damage	Impact of vessels on the TCRA armor rock could result in armor rock being moved

3.2 Primary Cause Identified

This section describes the primary cause that triggered the need for maintenance.

3.2.1 Localized Areas of Steeper Cap Subgrade Slopes

In the maintenance areas of the western berm, it was noted that the underlying berm cap subgrade (covered by geotextile) was as steep as 1 horizontal to 1 vertical (1H:1V) over short distances (approximately 1 to 2 feet high) and in limited areas. Prior to construction of the TCRA cap, the steepest slopes at the impoundments north of I-10 were observed to be approximately 2H:1V, and the stability of 2H:1V slopes was evaluated in the TCRA RAWP (Anchor QEA 2010) and determined to be acceptable.

Locally steeper areas appear to be the result of the clearing and grubbing operations on the western berm, which occurred prior to capping. Clearing and grubbing, and removal of larger root wads would have resulted in pockets of material being moved around, which could have caused localized steeper areas in these pockets.

This root cause assessment is supported by a review of photographs (Appendix A) taken during the capping of the western cell. In one photograph, portions of the outer face of the western berm subgrade that are covered in geotextile (but prior to armor rock placement) appear to be steeper than the design 2H:1V slope.

Because the cap subgrade was steeper than 2H:1V in these isolated areas, there were zones of armor cap rock that were more susceptible to wave and current attack on the berm face.

3.3 Contributory Cause

While the localized steep conditions of the western berm cap subgrade are the primary factor that triggered the need for maintenance, one secondary or contributory cause was also identified during the review. This cause is considered "contributory" because it would not have independently triggered the need for maintenance if not for the primary cause that was identified previously.

Water surface elevations during July 7 through July 19, 2012 are modeled to have ranged from approximately +2 to +5 feet North American Vertical Datum of 1988 (NAVD88), which coincides with the range of elevations (toe to crest) along the western berm face (Figure 8). Wind-generated waves were evaluated using the meteorological data during this same period using the methods described in Section 2.1. Based on this evaluation, it is estimated that a significant wave height of 0.85 feet, with a period of 1.7 seconds, could have been generated at peak wind times, along the outer face of the western berm.

Given the water levels that occurred during July 2012, and in the presence of locally steeper faces along the berm as described above, it is reasonable to conclude that wave action at this range of water levels would have been sufficient to cause cap aggregate movement in the isolated areas where the berm subgrade conditions were steeper than 2H:1V. Thus, while the wind-generated waves and water levels experienced during the July 2012 storm would not independently have triggered a need for maintenance, they could have been a contributory factor when coupled with the primary cause identified in Section 3.2.

3.4 Other Potential Causes

This section describes other factors that were evaluated, but were ultimately ruled out as potential causes triggering the need for maintenance along the western berm face.

3.4.1 Soft Berm Foundation Soils

Soft berm foundation soils could potentially lead to a deep-seated, global stability issue with the western berm. Deep-seated failure mechanisms manifest themselves with distinct visual cues. Indications of a deep-seated berm failure would include the presence of a scarp, or vertical face, at the top of the berm, combined with a bulge at the toe of the berm, indicating a rotational failure of the berm and subgrade has occurred.

During the inspections of the western berm, visual cues that would indicate a deep-seated failure were not observed. In addition and as described in Section 2, the slope stability factor of safety along the western berm was evaluated to be greater than 1.0. Thus, potentially soft berm foundation soils were ruled out as a potential cause for the maintenance requirement.

3.4.2 Armor Cap Gradation

As discussed in Section 2, the gradation of the cap as designed is appropriate to protect against the anticipated wind and vessel-generated waves at the TCRA Site. The contractor demonstrated that the cap materials met the required gradation by providing gradation test results as pre-construction submittals. Because the reassessment confirmed that the cap gradation is appropriately protective, this factor was ruled out as a potential cause for the maintenance requirement.

3.4.3 Construction Loads

Construction equipment operated within the western cell boundaries during armor rock placement. As described in Section 2.2, the construction equipment operated on top of wooden crane mats to distribute the equipment load more evenly on the cap surface.

Long-reach excavator equipment operated in the vicinity of the western berm in order to place armor rock to the western limits of the TCRA cap. During this placement, the excavators approached the western berm but did not work on top of the berm.

The geotechnical reassessment considered the potential impact of construction loads operating directly on top of the western berm, as described in Section 2.2. This evaluation concluded that the FOS for slope stability exceeded 1.1 during construction, using a conservative series of assumptions about the strength of the berm subgrade, the slope of the berm subgrade, and the proximity of the construction surcharge load to the outer crest of the berm. A FOS in excess of 1.0 indicates that the slope is stable with respect to sliding (USACE 2003).

Based on these considerations, the construction load factor was ruled out as a potential cause for the maintenance requirement.

3.4.4 Elevated River Currents

Wet weather in the Houston area during July 2012 resulted in elevated storage stage behind the Lake Houston dam. Based on stage heights at the dam and water levels measured in the Houston Ship Channel at the Morgan's Point tide gauge, the flow in the San Jacinto River was calculated to be a 2-year return interval flow based on flood frequency evaluation, with a maximum flow computed to be between 0.8 and 1 meter per second adjacent to the TCRA Site and less than 0.2 meters per second in the vicinity of the western berm. These flows were compared to the median cap grain size for the Armor Cap B/C material (the cap type that was used on the western berm). Under the flows that resulted from the July 2012 weather, the Armor Cap B/C material was found to be stable. Thus, elevated river flow rates were ruled out as a potential root cause.

3.4.5 Impact and Anthropogenic Damage

Impact and anthropogenic damage (e.g., boat anchoring, vandalism) were visually assessed during the inspection. In all areas where the geotextile was visually observed, the geotextile was clean and undamaged. Impact or anthropogenic damage would be expected to have damaged or marked the underlying geotextile. Because such conditions were not observed, this potential root cause was ruled out.

3.5 Conclusions

The primary factor triggering the need for maintenance on the western berm was the presence of localized, steeper cap subgrade conditions. These conditions are presumed to have occurred during the clearing and grubbing activities. Contributing factors are associated with the July 2012 storm event, which resulted in wind-generated wave attack along the face of the western berm. These wind-generated waves had the potential to move the finer-grained fraction of the armor rock, which could have triggered down-slope movement of the larger fraction of the Armor Cap B/C aggregate in those limited areas of the western berm that were steeper than 2H:1V.

During the July 2012 maintenance activity, additional stone was placed along the face of the western berm to create a slope that is 2H:1V or flatter. The work completed during this maintenance activity addressed the primary factor identified by this reassessment effort. Details on the July 2012 maintenance activity are provided in the August 27, 2012 TCRA Maintenance Completion Report submitted to USEPA.

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FIGURES

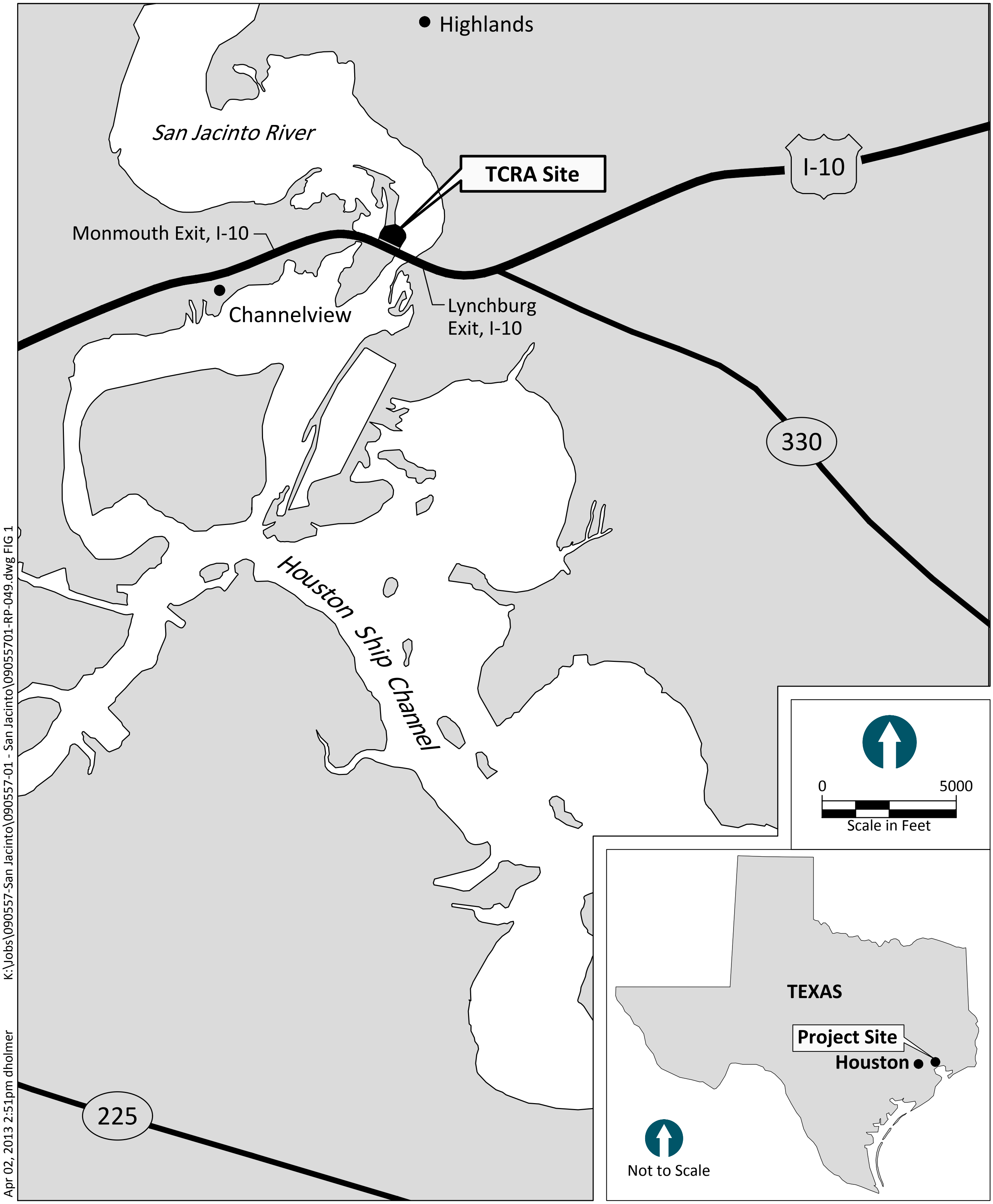
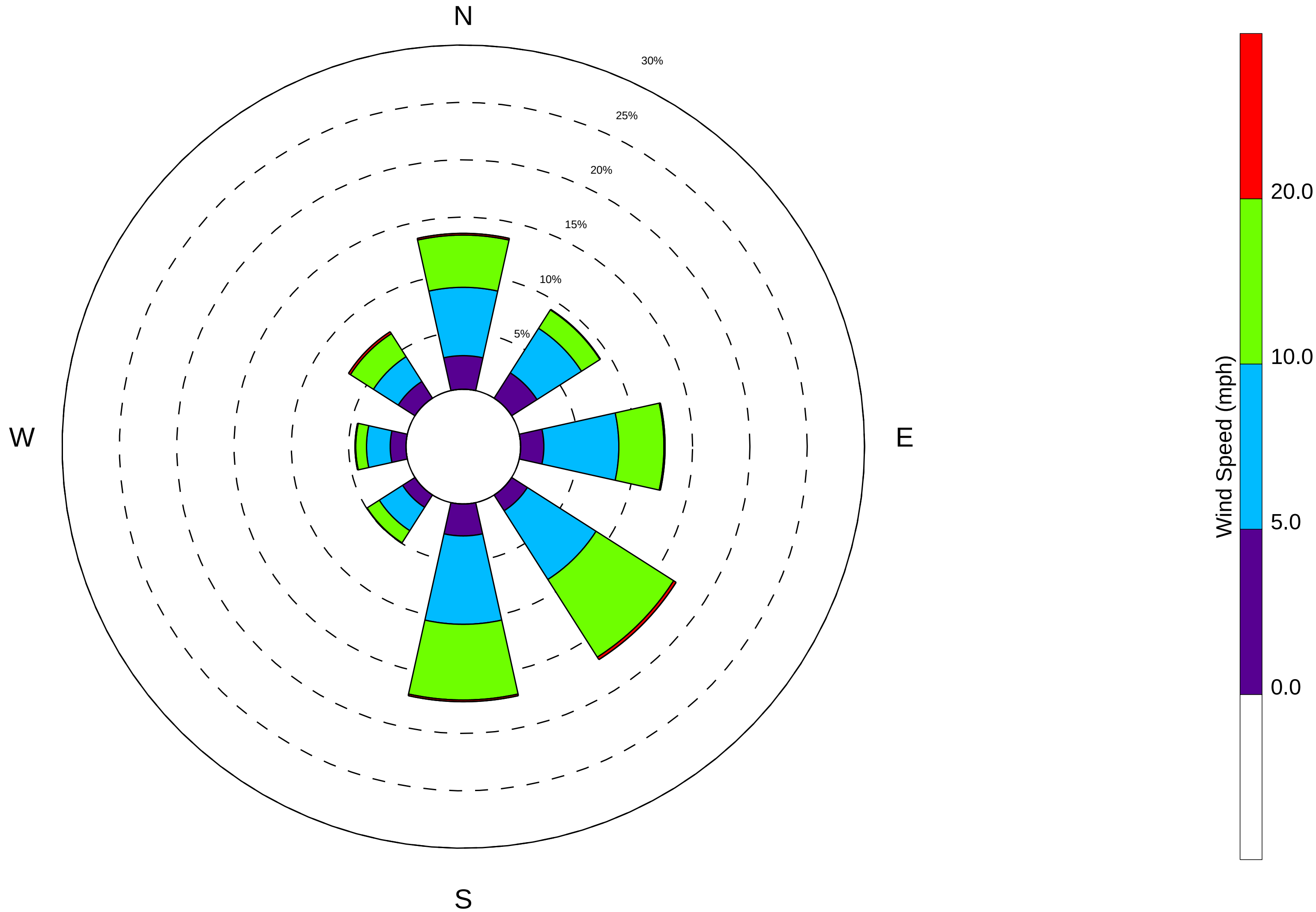


Figure 1
Vicinity Map
Reassessment of TCRA Design and Construction
San Jacinto Waste Pits Superfund Site

ANCHOR QEA



Calm Winds 14.1%
Maximum Recorded Wind Speed: 63.3 mph

Figure 2
Wind Rose Diagram
Reassessment of TCRA Design and Construction
San Jacinto River Waste Pits Superfund Site

ANCHOR QEA

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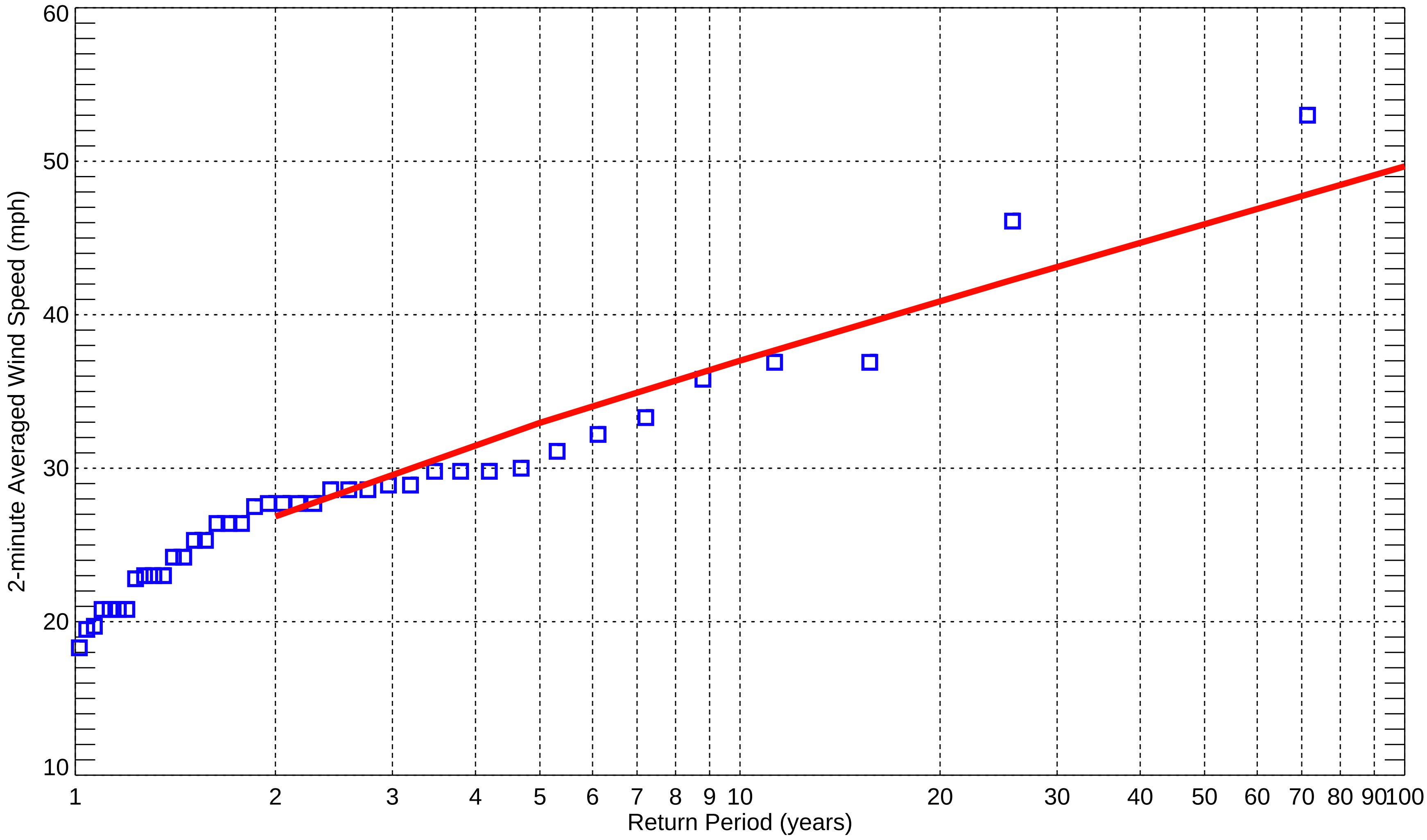
Figure 3
Fetch Distances
Reassessment of TCRA Design and Construction
San Jacinto River Waste Pits Superfund Site



Annual Maximum Winds
Fisher-Tippett Type 1 (FT-1) Distribution

Figure 4

Return Interval Wind Speeds (North)
Reassessment of TCRA Design and Construction
San Jacinto River Waste Pits Superfund Site

The wind record is from 1973 to 2012 at the George Bush Intercontinental Airport

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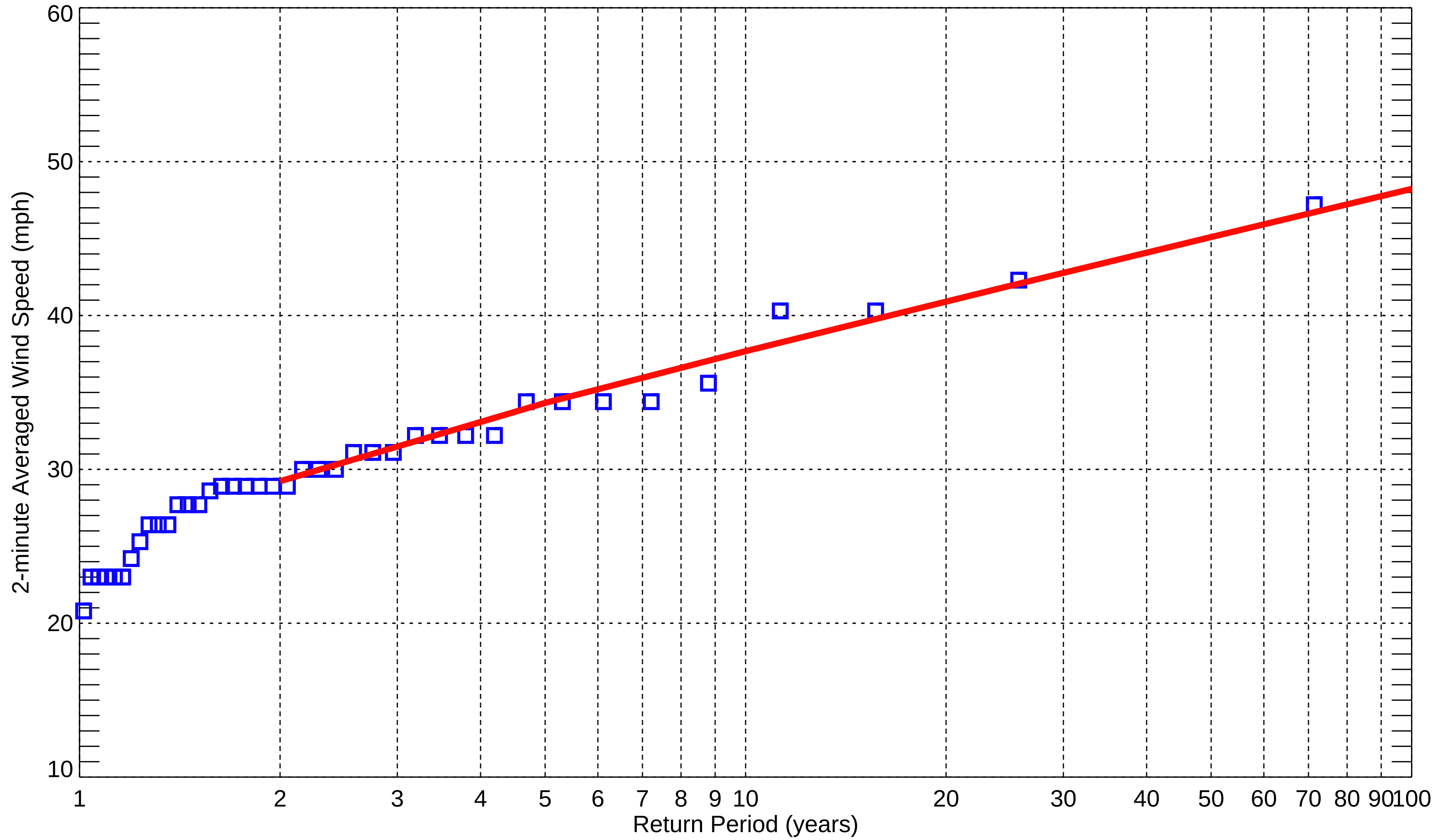

ANCHOR QEA

Figure 5

Return Interval Wind Speeds (Northwest)
Reassessment of TCRA Design and Construction
San Jacinto River Waste Pits Superfund Site

The wind record is from 1973 to 2012 at the George Bush Intercontinental Airport

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K:\Projects\0557-McGinnes Industrial Maintenance Corp\San Jacinto Waste Pits_TCRA Reassessment Report\0557-RR-FIG6.dwg Fig 6

Mar 28, 2013 8:55pm jlaplante

SOURCE: Drawing prepared from aerial photo by Bing.
HORIZONTAL DATUM: Texas State Plane South Central, NAD83, U.S. Feet.

0 500
Scale in Feet

Figure 6
Location of SJRF Operations
Reassessment of TCRA Design and Construction
San Jacinto Waste Pits Superfund Site

LEGEND:

Post-Construction Contour, 8/19/11 to 9/2/11 (1-foot interval)

Historic Impoundment Limit (USEPA)

Approximate Limits of Maintenance Activity

Surveyed Area of Steeper Slopes

HORIZONTAL DATUM: Texas South Central, NAD83. US Survey Feet.
VERTICAL DATUM: NAVD88.

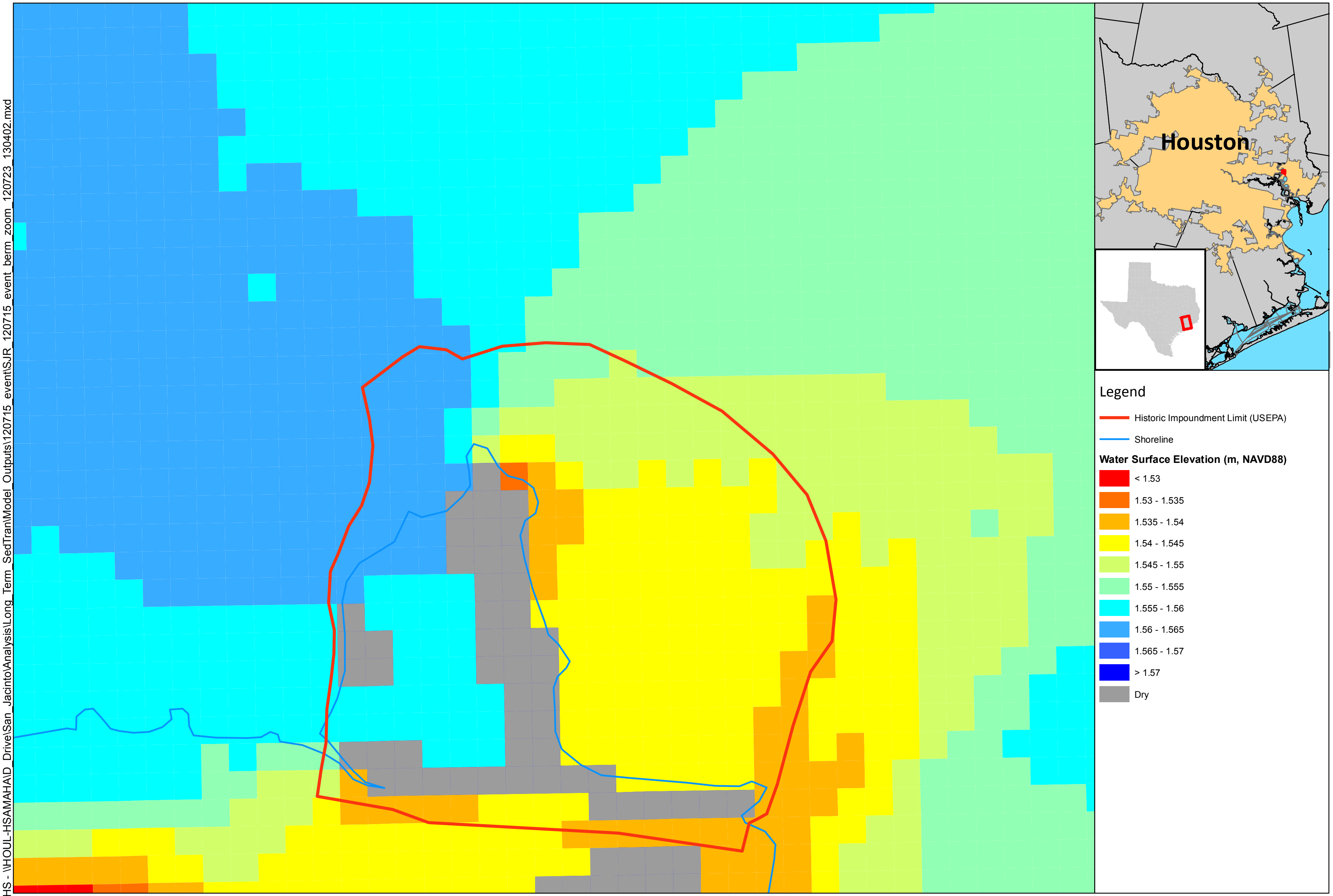
0 120
Scale in Feet

C:\Users\jlaplante\appdata\local\temp\AcPublish_25372\0557-RR-002.dwg FIG 7

Mar 29, 2013 8:48am jlaplante

ANCHOR QEA

Figure 7
TCRA Maintenance Event Areas
Reassessment of TCRA Design and Construction
San Jacinto River Waste Pits Superfund Site



ANCHOR QEA

0 250 500
Feet

Figure 8
Peak Water Levels – July 7 to 19, 2012
Reassessment of TCRA Design and Construction
San Jacinto River Waste Pits Superfund Site

APPENDIX A
JANUARY 16, 2013 PRESENTATION MATERIALS

USEPA – Western Cell Cap Maintenance Questions and Answers

San Jacinto River Waste Pits Superfund Site
January 16, 2013

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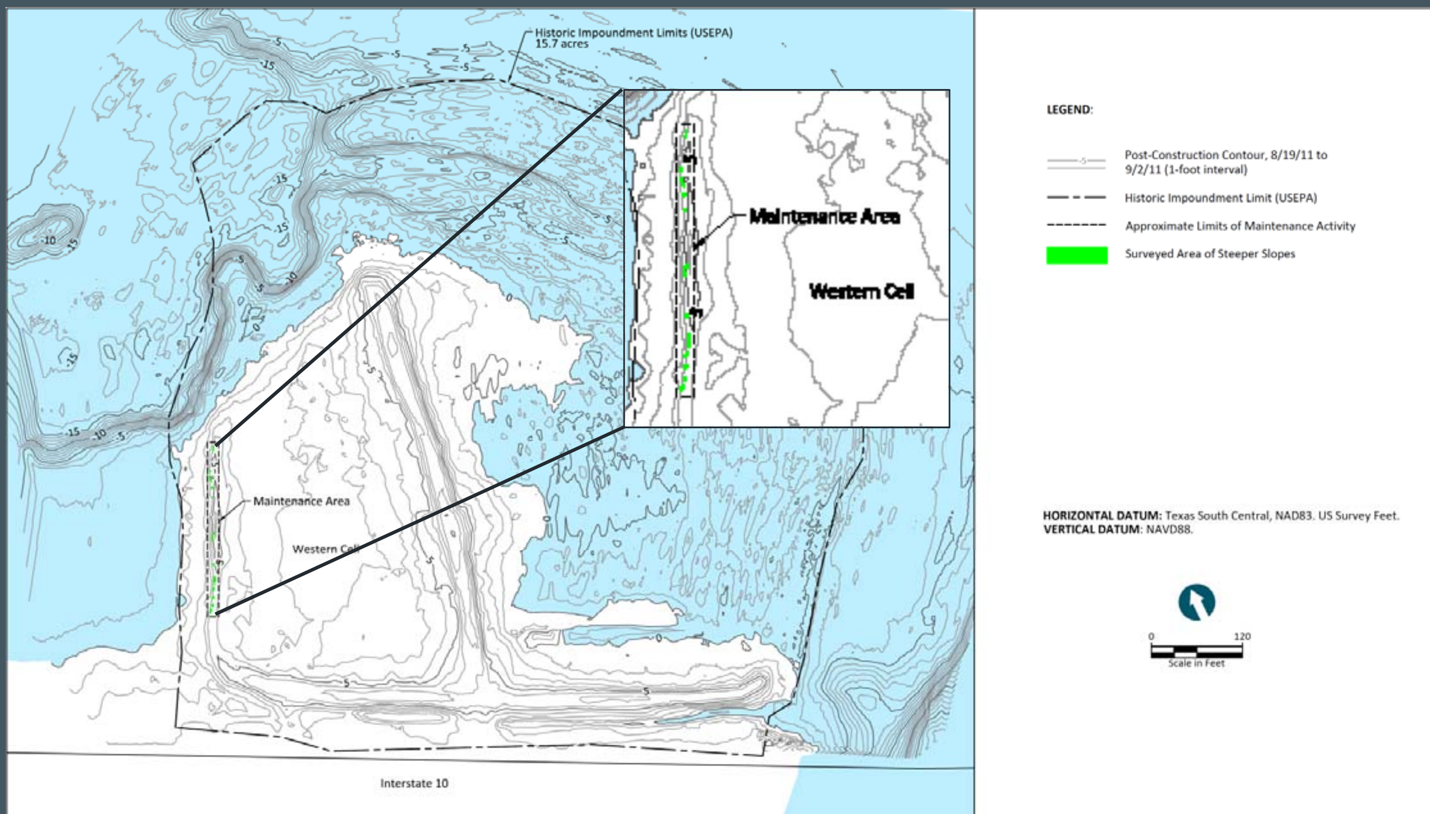
TCRA Construction - 2011



2

ANCHOR QEA

TCRA Construction - 2011

Western berm following construction. (Photograph: 2011-07-07.01)

3

ANCHOR QEA

TCRA Construction - 2011

Question 1- What type of construction equipment was used to place the armor cap material [on the western berm]?

Answer 1 - Before placement of armor cap material on the western berm, the contractor utilized excavators (CAT 320D L and Komatsu PC300LC) on mats and hand labor to clear and grub the area.

After the clearing and grubbing was completed, the following equipment was used to place the armor cap material within the Western Cell:

1. Skid steers (CAT 226B and Bobcat T250) and dozer (CAT D5K LGP), which were used to place leveling course material and armor rock within the Western Cell.
2. Hand tools, which were used by laborers who deployed geotextile and geomembrane.
3. Long-reach excavators (CAT 324D L and JCB 260), which were used on mats for soil stabilization.
4. A long-reach excavator (CAT 324D L), which was used on mats to place armor rock.
5. Morooka trucks (MST-2200), which were used to transport armor rock.

TCRA Construction - 2011

Answer 1 Continued -

Examples from daily reports that reference equipment operations include:

1. Long-reach excavator working to clear vegetation from the Western Cell (April 1, 2011 – No. 072)
2. Long-reach excavator installing interim berm in Western Cell (May 5, 2011 – No. 096)
3. Long-reach excavator stabilizing upland soils in the Western Cell (May 17, 2011 – No. 105)
4. Skid steers working in the Western Cell to place crushed concrete road base (CCRB) (May 20 to May 23, 2011 – Nos. 108 to 110)
5. Geotextile and geomembrane installation (May 25 to June 2, 2011 - Nos. 112 to 118)
6. Skid steer placing B/C armor rock near the central berm in the Western Cell (June 6, 2011 - No. 121)
7. Long-reach excavator placing B/C armor rock across the western berm (June 7, 2011 - No. 122)

TCRA Construction - 2011

Smoothing the ground surface in the Western Cell in preparation for geotextile deployment. (Daily Report – April 1, 2011 No. 72)

6

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TCRA Construction - 2011

Clearing vegetation along the western berm of the Western Cell in preparation for geotextile deployment. (Daily Report – April 4, 2011 No. 73)

7

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TCRA Construction - 2011

Skid steer grading CCRB across the surface of the Western Cell.
(Photograph: 2011-05-23.02)

8

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TCRA Construction - 2011

Western berm of the Western Cell. (Photograph: 2011-05-20.11)

9

ANCHOR QEA

TCRA Construction - 2011

Deploying geotextile outside the western berm of the Western Cell.
(Photograph: 2011-05-31.13)

10

ANCHOR QEA

TCRA Construction - 2011

Geotextile deployed along the western berm and to the west of the Western Cell. (Photograph: 2011-06-01.02)

ANCHOR QEA

TCRA Construction - 2011

Western berm following construction. (Photograph: 2011-07-07.01)

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TCRA Construction - 2011

Western Cell following construction completion. (Photograph: 2011-07-14.14)

13

TCRA Construction - 2011

Question 2 - How heavy was this equipment?

Answer 2 - The contractor's equipment make and model and the manufacturers' estimated weights are as follows:

- Long-reach excavator (clearing and grubbing, soil stabilization, and armor rock placement) - CAT 324D L – Operating Weight 61,600 lbs.
- Long-reach excavator (soil stabilization) – JCB 260 – Operating Weight 63,558 lbs.
- Excavator (clearing and grubbing) – CAT 320D L - Operating Weight 47,950 lbs.
- Excavator (clearing and grubbing)– Komatsu PC300LC – Operating Weights 69,490 – 71,160 lbs.
- Skid steers (leveling course and armor rock placement) - CAT 226B and Bobcat T250 - Operating Weights 5,822 lbs and 9,121 lbs, respectively.
- Dozer (leveling course placement) – CAT D5K LGP – Operating Weight 21,347 lbs.
- Morooka trucks (armor rock delivery) – MST-2200 – Operating Weight 27,006.60 lbs.

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TCRA Construction - 2011

Question 3 - How close to the western berm did the equipment have to be in order to effectively place the armor cap material?

Answer 3 - The equipment worked from the interior of the western berm parallel to, but not atop the western berm. The photographs in the following slides depict the location of the equipment relative to the berm.

Daily reports for the period from June 3 to 8, 2011 (Nos. 119 to 123) included photographs of the cap placement activities near the western berm. The following photographs show times when equipment was working closest to the western berm:

- Photograph taken on June 3, 2011 shows the long-reach excavator near the southwest corner, where the long-reach excavator could position itself directly on the southern berm.
- On June 7, 2011, the long-reach excavator was located on the interior side of the Western Cell in order to place the armor rock on the western edge of the cap.

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TCRA Construction - 2011

Placing B/C armor rock outside the southwest corner of the Western Cell. (Daily Report – June 3, 2011 No. 119)

ANCHOR QEA

TCRA Construction - 2011

Placing B/C armor rock across the western berm in the Western Cell.
(Daily Report – June 7, 2011 No. 122)

17

TCRA Construction - 2011

Western Cell stabilization adjacent to the western berm.
(Photograph: 2011-05-17.10)

18

ANCHOR QEA

TCRA Construction - 2011

Question 4 - Did any of the equipment used during placement of the armor cap material along the western berm damage, reshape, create a bulge, or otherwise affect the berm?

Answer 4 - No, the way the equipment was used during the placement of the armor cap materials would not have "damaged, reshaped, created a bulge, or otherwise affected" the berm.

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TCRA Construction - 2011

Question 5 - Did any activities conducted during the site removal action damage or affect the shape or slope of the western berm?

Answer 5 – During clearing and grubbing the removal of trees and overbrush resulted in some changes to the general contours of the land. In general, the TCRA resulted in a flattening of the slope of the western berm.

TCRA Construction - 2011

Question 6 - What was the original slope of the Armor Cap B/C material placed on the western berm? Did the original slope placement contribute to the strength or instability of the western berm?

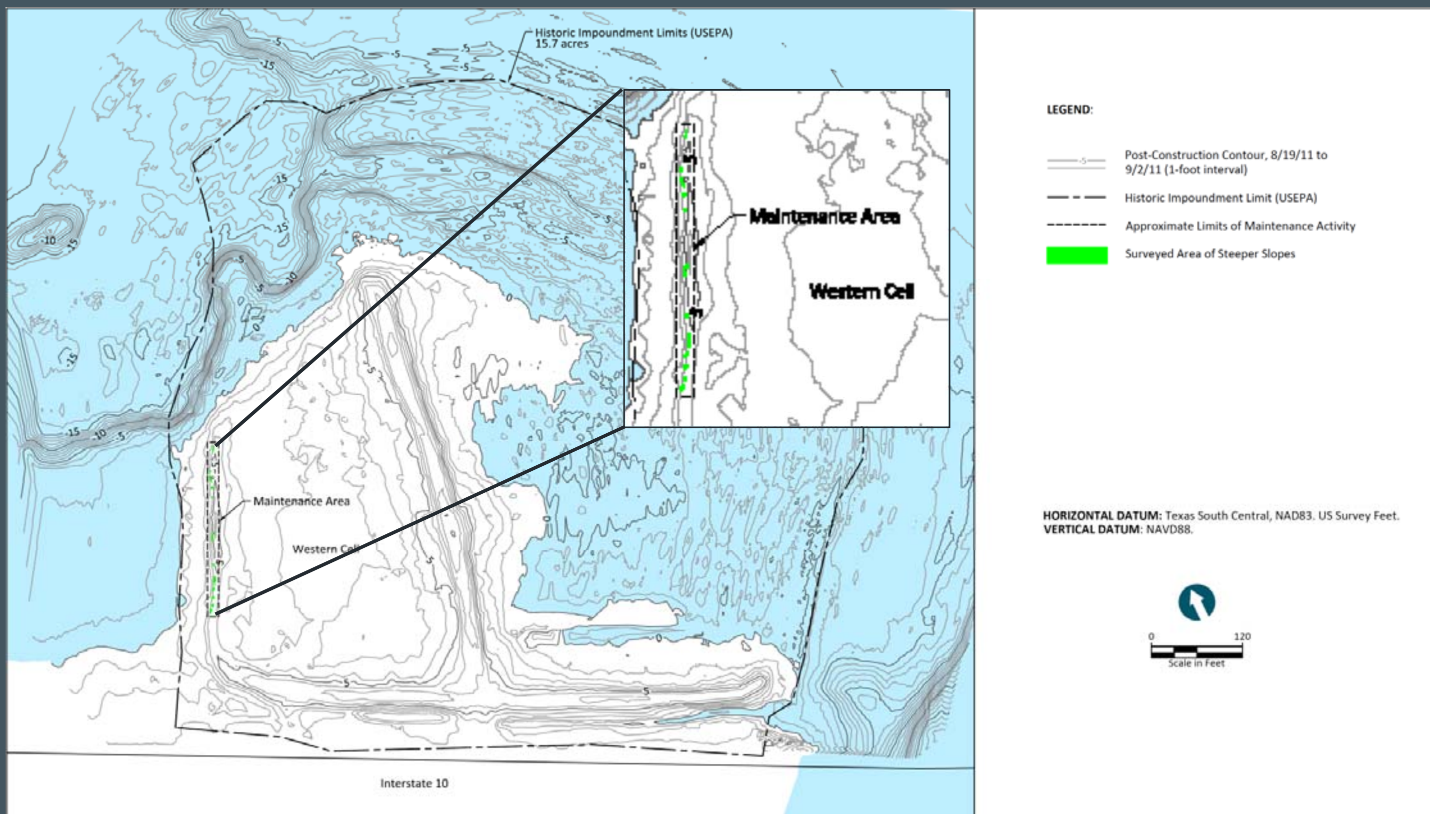
Answer 6 - The outside slope of the armor was designed to be constructed to a grade of 2H:1V or flatter. Based on post-construction survey and visual inspections, the finished grade armor rock covered the western berm at 2H:1V or flatter over larger scales.

The survey data and visual inspection showed the design slopes of 2H:1V were achieved. Areas were identified during the repair activity planning for the western berm using detailed topographic survey techniques and showed small scale slopes that were steeper than 2H:1V along the western berm. The total area with those steep slopes was about 80 square feet and is shown on the following slide.

21

ANCHOR QEA

TCRA Construction - 2011



22

ANCHOR QEA

TCRA Construction - 2011

Question 7 - What quality construction [sic] quality control documents are available that document that the proper slope was achieved during placement of the armor cap material along the western berm?

Answer 7 - Post-placement topographic surveys are available that document the final slope of the western berm and other areas of the TCRA cap. See post-construction probing and survey data provided by USA Environment, LP in the Removal Action Completion Report (RACR).

Surveys of the in-place armor cap and geotextile/geomembrane layers are provided in the RACR (Section 6 – Land-side Construction Activities). The final armor cap thickness probing survey is also included in the RACR (Section 8 – Final Inspections and Certifications).

ANCHOR QEA

TCRA Construction - 2011

Question 8 - What quality construction [sic] quality control documents are available that document the actual percentage of fines used in the construction did not exceed the minimum design requirements specified for the B/C armor cap material during placement along the western berm?

Answer 8 - Quality control documents from the contractor and its vendors are available, and were provided to USEPA during the construction (gradation testing results for the B/C armor rock were provided in Submittal 12 to USEPA, on March 1, 2011). The next slide provides a table listing each of the contractor's submittals pertaining to the materials placed at the TCRA Site.

ANCHOR QEA

TCRA Construction - 2011

Submittal Date	Submittal Number	Description
February 2, 2011	06	Natural Stone – Chemistry
February 15, 2011	06A	Natural Stone – Chemistry Revised
February 2, 2011	07	Natural Stone – Gradation for Armor Cap C
February 2, 2011	08	Natural Stone – Gradation for Armor Cap D
February 9, 2011	12	B/C Material Gradation
February 15, 2011	14	Processed Concrete – Chemistry
March 9, 2011	18	Grain Size Analysis – Blended Armor Cap A Material
April 6, 2011	19A	Natural Stone – Chemistry – Second Sample
April 18, 2011	21	Natural Stone – Chemistry – Third Sample
April 19, 2011	22	Processed Concrete – Chemistry – Second Sample
May 11, 2011	23	Bank Sand - Chemistry
June 22, 2011	24	Concrete B/C Material - Chemistry

Note:
1. Dates shown are submittal dates to Anchor QEA.

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ANCHOR QEA

TCRA Construction - 2011

Question 9 - Did the hydrodynamic modeling used to determine the slope and the size and area placement of the armor cap material consider the erosional impacts due to wave action from the San Jacinto River along the western berm?

Answer 9 - The analysis of hydrodynamic forces included wind- and vessel-generated waves. A design analysis was performed to evaluate the potential wind- and vessel-generated wave heights that could impact the TCRA Site from the San Jacinto River, as well as the stable particle size required to resist these potential wave heights. Return interval wind-generated wave heights were computed using long-term wind measurements from the George Bush Intercontinental Airport in Houston, Texas. Vessel-generated waves (vessel wakes) were computed based on vessel types and operational patterns observed near the TCRA Site.

The result of this analysis was that wind-generated waves and vessel wakes were expected to be less than 2 feet at the TCRA Site. Both natural stone aggregates and recycled concrete aggregates with a D_{100} of 12 inches and a D_{50} of 6 inches will protect against waves in the surf zone at the TCRA Site on slopes 2H:1V or flatter.

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ANCHOR QEA

TCRA Maintenance - 2012

Question 10 - [With reference to the 2012 repairs], [w]hy was there considerable erosion along the entire length of the western berm and not along other areas of the armor cap?

Answer 10 - During that 2-week period in July, there were times when winds were blowing from the northwest at 25 mph and the elevation of the river was at the level of the berm. These conditions had the potential to impact the western berm and move material down the slope in localized areas in which the slope was steeper than 2H:1V.

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ANCHOR QEA

TCRA Maintenance - 2012

Question 11 - Was the Armor Cap C material actually used in the repair readily available in a nearby stockpile for maintenance or was it special ordered to repair and prevent future erosion along the western berm?

Answer 11 - The C armor rock material used for maintenance was stockpiled at a nearby location (Bluebonnet facility) for future O&M activities, as outlined in the RACR (Section 9.3.1 – Response Time) and as provided for in the Operations, Monitoring, and Maintenance (OMM) Plan (RACR – Appendix N; Section 3.2.2 – Armor Cap C and D).

These natural stone materials (C and D armor rock) require longer lead time than locally available processed concrete materials (A and B/C armor rock), and stockpiling of this material was provided for in the OMM Plan in order to allow for a quick response if repairs were necessary that required the use of these material types. No special order of material was necessary for the maintenance event.

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ANCHOR QEA

TCRA Maintenance - 2012

Stockpiling C armor rock at the off-site stockpile area.
(Daily Report – July 20, 2011 No. 153)

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TCRA Maintenance - 2012

Stockpiling C armor rock at the off-site stockpile area.
(Daily Report – July 20, 2011 No. 153)

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TCRA Maintenance - 2012

C armor rock (on left) and D armor rock (on right) stored at the off-site stockpile area. (Daily Report – July 22, 2011 No. 155)

TCRA Maintenance - 2012

C armor rock (on left) and D armor rock (on right) stored at the off-site stockpile area. (Photograph: 2011-07-22.05)

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ANCHOR QEA

TCRA Future Maintenance

Question 12 - [In reference to future maintenance and repairs], [i]s the Armor Cap gradation A or B/C material "stable" for use in future maintenance of armor cap erosion? If not, why use this size of material in the cap construction?

Answer 12 - The selection of the particle size gradations for all cap materials was evaluated using a hydrodynamic model and the USEPA guidance document: *Armor Layer Design for the Guidance for In-Situ Subaqueous Capping of Contaminated Sediments*, as well as the USACE methods to determine wind-generated waves, vessel wakes, and the size of materials to withstand these wave forces.

The recommended size for all cap material was based on armor design factors of safety and design procedures recommended by the USACE in Appendix A of the USEPA capping guidance document cited above, which have been used at other CERCLA cleanup sites.

TCRA Future Maintenance

Question 13 - If there are five different types of armor cap material used during the construction, are there five different stockpiles of material readily available for maintenance? If not, why not?

Answer 13 - The stockpiling of materials for maintenance activities was addressed in the OMM Plan. There are four aggregate sizes; D24 is a 24-inch thick layer of the D armor rock. The OMM Plan provided for the stockpiling of C and D armor rock. The stockpiles are for the natural stone with a long testing, processing, and delivery lead time (C and D armor rock).

As outlined in the OMM Plan, these materials are larger than the A and B/C armor rock and can be substituted for those materials with a higher level of protection during maintenance events.

APPENDIX B
SUMMARY OF TCRA CONSTRUCTION SUBMITTALS

Submittal No.	Description	Specification Section Reference	Date Submitted to Anchor QEA	Date Provided to USEPA	Anchor QEA Response
1	Filter fabric for road/access area underlay for TxDOT Property	RAWP Appendix C Section 3.1.7.2 as modified per TxDOT Access Agreement	1/25/2011	2/1/2011	Conforms to design concept
2	Filter geotextile beneath the cap layers	RAWP Appendix C Section 3.2.3.2	1/24/2011	2/1/2011	Conforms to design concept
3	Geomembrane	RAWP Appendix C Section 3.2.4.2	2/1/2011	2/1/2011	Conforms to design concept
4	Contractor Health and Safety Plan	RAWP Appendix G Section 5.1.3	2/2/2011	2/2/2011	Conforms to design concept
5	Geomembrane bedding geotextile	RAWP Appendix C Section 3.2.4.2	2/2/2011	2/2/2011	Conforms to design concept
6	Natural stone chemistry (partial)	RAWP Appendix C Section 3.2.5.2	2/2/2011	2/3/2011	Conforms with revisions shown
6a	Natural stone chemistry (full)	RAWP Appendix C Section 3.2.5.2	2/15/2011	3/1/2011	Conforms to design concept
7	Armor Cap C gradation	RAWP Appendix C Section 3.2.5.2	2/2/2011	2/3/2011	Conforms to design concept
8	Armor Cap D gradation	RAWP Appendix C Section 3.2.5.2	2/2/2011	2/3/2011	Conforms to design concept
9	List of subcontractors	For information purposes	2/2/2011	2/3/2011	For information
10	Contractor Work Plan (CWP), a.k.a. Project Work Plan (PWP)	RAWP Appendix G Section 5.1.1	2/3/2011	2/4/2011	Conforms with revisions shown
11	Environmental Protection Plan (EPP) and Stormwater Pollution Prevention Plan (SWPPP)	RAWP Section 3.7.1.4 RAWP Appendix G Section 5.1.4	2/4/2011	2/4/2011	Conforms to design concept
12	Armor Cap B/C gradation	RAWP Appendix C Section 3.2.5.2	2/9/2011	3/1/2011	Conforms to design concept
13	Site Security Plan (SSP)	RAWP Appendix C Section 3.1.4	2/9/2011	N/A	Conforms to design concept
13a	Site Security Plan (SSP) - Revised	RAWP Appendix C Section 3.1.4	2/28/2011	3/1/2011	Conforms to design concept
14	Processed concrete chemistry	RAWP Appendix C Section 3.2.5.2	2/15/2011	3/1/2011	Conforms to design concept
15	Draft Emergency Contingency Plan	Requested by USEPA	2/18/2011	2/18/2011	For information
15a	Emergency Contingency Plan	Requested by USEPA	3/11/2011	3/17/2011	For information
16	Contractor Quality Control Plan (CQC) a.k.a. Quality Management Plan (QMP), including Survey Control Plan	RAWP Appendix G Sections 5.1.2 and 5.1.6	2/22/2011	2/23/2011	Conforms to design concept
17	LLDPE test results	For information purposes	3/3/2011	3/10/2011	For information

Submittal No.	Description	Specification Section Reference	Date Submitted to Anchor QEA	Date Provided to USEPA	Anchor QEA Response
18	Armor Cap A gradation	RAWP Appendix C Section 3.2.5.2	3/9/2011	3/10/2011	Conforms to design concept
19	Natural Stone Chemistry - Test #2	RAWP Appendix C Section 3.2.5.2	4/6/2011	4/14/2011	Conforms to design concept
20	Revised Contractor Health and Safety Plan	RAWP Appendix G Section 5.1.3	3/21/2011	4/14/2011	Conforms to design concept
21	Natural Stone Chemistry - Test #3	RAWP Appendix C Section 3.2.5.2	4/18/2011	5/5/2011	Conforms to design concept
22	Processed concrete chemistry - Test #2	RAWP Appendix C Section 3.2.5.2	4/19/2011	5/5/2011	Conforms to design concept